Students at the Centre: Teacher Understandings and Applications of Student-Centered Learning in Grade 9 and 10 Science

By

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Abstract

This study aims to shed light on and investigate strategies to alleviate the issue of decreased student engagement in Ontario intermediate (Grade 9 and 10) science classes, which is evident in the literature. Semi-structured interviews were conducted with three purposefully selected intermediate science teachers within the Toronto Catholic District School Board (TCDSB) on the topic of student-centered learning (SCL) and implementation of problem-based learning (PBL) in their science classrooms. Educators were asked about their personal experiences with implementation of such strategies, including their opinions regarding the value of PBL as a student-centered approach to science instruction. Findings revealed several key themes: teachers observe students’ focus on marks as a limit to risk-taking and deeper inquiry; teachers advocate for development of “lifelong learners” as a primary goal of their PBL practice; and teachers report a need for increased professional development in student-centered instruction and PBL. The study’s implications and recommendations target several stakeholders in education including teachers, administrators, policy-makers, and pre-service education programs. It is a conclusion of this study that, although teachers are aware of and sometimes implement such strategies, there is much progress to be made in teacher understanding and confidence in implementation of effective student-centered instruction in intermediate science teaching practice.

Key Words: teacher perceptions, student engagement, intermediate science, student-centered learning/instruction, problem-based learning, risk-taking
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Chapter 1: Introduction

1.0 Introduction: Research Context and Problem

Finding the connection between what students are required to learn and what students would prefer to learn in the classroom is (and may forever be) an ongoing struggle for educators and policy-makers across the globe. The paradigm shift from teacher-centered to student-centered learning is a critical turning point in our pursuit of quality education for all, as it unlocks the opportunity for radical growth and development on a variety of local and global platforms. Science education in particular is considered to be one of the most important contributors to the development of analytical, creative, and rational thinkers (Kolodner et al., 2003). Understanding the way systems work, optimizing resources, and creatively implementing strategies for growth are only small pieces of the valuable skill-set acquired with quality science education. What nation wouldn’t want their citizens to possess these qualities?

The *Ontario Science Curriculum for Grades 9 and 10* (Ontario Ministry of Education [OME], 2008) clearly states that “[t]he notion of thriving in a science-based world applies as much to a small-business person, a lawyer, a construction worker, a car mechanic, or a travel agent as it does to a doctor, an engineer, or a research scientist” (p. 3). Despite the suggestion of universal relevance, both international and Canadian studies have shown a consistent decline in student engagement in science learning (Haste, 2004; Osborne, Simon, & Collins, 2001; Schreiner & Sjoberg, 2004).

To analyze and understand the affective reasons behind this disengagement, over forty countries (excluding both Canada and the United States) came together in a collaborative research effort titled the Relevance of Science Education (ROSE) Project (Sjorberg & Schreiner, 2010). Designed in 2004 and carried out in 2010 by Professor Svein Sjoberg, the initiative was designed to assess 15-year old students’ attitudes towards science learning through student
reports. Among a variety of interesting and often counter-intuitive results (discussed further in Chapter 2), the ROSE Project revealed student achievement in science to be negatively correlated with student attitudes. This means that even though students may perform well academically, their attitudes towards science learning remain largely negative or sceptical (Sjorberg & Schreiner, 2010).

It is remarkable that developed countries like Canada and the United States did not play a role in such an expansive and seemingly relevant project as the ROSE project. What then is Canada doing to promote student engagement in science classrooms? Turner and Peck (2009) discuss the Ontario curriculum dilemma of presenting relevant course content in their article on student engagement in Canadian science education by drawing attention to the dichotomy between “preparatory science” – science for those intending to pursue specialized careers in the sciences – versus “science for all” – science for those who will not be pursuing the subject past the mandatory level. Turner and Peck emphasize that the attained curriculum bears little similarity to its intent, despite the reshaping of the mandated Canadian curriculum in 1997 to account for scientific foundations outside of pure content and knowledge (i.e. social and environmental contexts, application and skills, and promoting positive attitudes). They go on to supplement this analysis with educator reports of students consistently failing to grasp the ‘Big Ideas’ outlined in the science curriculum (Turner & Peck, 2009). The question is then whether this disconnect is primarily an issue of the curriculum itself or of what happens when students and teachers work together on covering curriculum content in class.

The Oxford English Dictionary defines the term science as: “[the] intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experimentation” (Science, n.d.). In theory,
all science curricula should aim to cover each of the binaries in the Oxford definition, as follows: intellectual and practical activity, study of structure and behaviour in the physical and natural world, and study through both observation and experimentation. Analysis of the Grade 9 and 10 Ontario Science Curriculum (OME, 2008) reveals some very close parallels to this definition. In the Program Overview, we see that “all courses in the program are designed to focus on science not only as an intellectual pursuit but also as an activity-based enterprise within a social context” (p. 11). The five strands of organization – scientific investigation skills, biology, chemistry, earth and space science, and physics – then go on to cover the remaining binaries highlighted in the Oxford definition. In the first strand, Scientific Investigation Skills and Career Exploration, students learn the basics of both observational and experimental study methods; in the remaining four strands - Biology, Chemistry, Earth and Space Science, and Physics - students are exposed to the study of structures and behaviours in the physical and natural worlds. In a section devoted to assessment and evaluation, the document explicitly states how these strategies should be used to “improve student learning”, “guide teachers in adapting curriculum and instructional approaches to student’s needs”, and “[assess] the overall effectiveness of programs and classroom practices” (p. 22). Ultimately, the document details the benefits of experiential learning and emphasizes the role of inquiry and research, information and communications technology, and career exploration in the sciences.

Based on this analysis, the Ontario Grade 9 and 10 Science Curriculum (OME, 2008) appears to be explicit in promoting positive student attitudes toward science education. Therefore, attention must be focused on curriculum delivery within the classroom. To draw the bridge betwixt intended and attained curriculum, educators need to be well equipped with strategies where individual student interests and relatable content are not simply welcomed in
discourse, but provide the root for growing scientific inquiry in direct synchrony with curricular content. The question then becomes: what do these kinds of strategies look like?

Student centered learning (SCL) is a teaching approach defined by Odom, Stoddard, and La Nasa (2007) as “the process of constructing declarative and procedural knowledge, which can be initiated and guided by a question or problem, requiring students to negotiate how to answer the question or solve the problem through discussion” (p. 88). This style is juxtaposed against more traditional teacher-centered approaches such as lecturing and demonstrations, requiring further exploration beyond the textbook or standard demonstrations to effectively bring students’ social contexts into the classroom. Bell and Odom (2015) describe the passive nature of teacher-centered instruction in middle school science classrooms, insisting that without tangible interaction with materials or social interaction with peers, students are deprived of active learning opportunities. In this same way, the ability to acquire procedural knowledge (know how) – highlighted above as a product of SCL – is vastly limited as students are exposed to and tested only in declarative knowledge (know what) (Lawson, Abraham, & Renner, 1989). In this regard, passive learning through teacher-centered instruction produced not only diminished conceptual understanding of course content, but also manifested in decreasing students’ positive attitudes towards science learning. To counter-act this ever-present cycle of teacher-centered instruction in middle school science classrooms, Bell and Odom (2015) set out to explore the effects of increased implementation of SCL strategies (in this study’s case they used interactive laboratory investigations) on student attitudes towards science learning. As predicted, the researchers found a strong positive correlation between frequency of SCL and positive affect towards science learning, providing support for the pursuit of knowledge in this particular educational approach.
Problem-based Learning (PBL) is a student-centered instructional method developed by Dr. Howard S. Barrows and Robyn M. Tamblyn during the mid 1960s at McMaster University. Originally designed for medical education, PBL consisted of medical case studies where students tackled pre-designed problems that facilitated movement towards the learning goals for those individuals at a particular time (Barrows & Tamblyn, 1980). Despite its specific original intent, the principles of PBL can be universally applied to nearly all aspects of education, the common goal being a combination of knowledge attainment (declarative) and application/development of skills (procedural). The most prominent advantages of PBL highlighted by Barrows and Tamblyn (1980) are content memory associated with problem-solving, critical thinking, obvious relevance to student reality, and positive affect towards the pursuit of discovery. On the other hand, decreased attention to content-specific learning, time constraints, and insufficient preparation for standardized testing are some of the reported drawbacks of PBL.

Growing more popular with the evolution of curriculum and practices in education, PBL is now one of many student-centered educational strategies circulating in both elementary and high school classrooms. Such activity-based methods like Learning by Design or LBD (Kolodner et al., 2003), Self-Directed Learning or SDL (Hmelo-Silver, 2004), Project-Based Science or PBS (Kanter, 2010), and many others, are becoming more prominent extensions of PBL in literature surrounding student-centered learning. This study will refer more specifically to PBL and LBD as the highlighted subsets of SCL, though it is important to be aware of the many variations. Despite their slightly differing labels, all of these teaching strategies have one
common effect: the potential to foster student learning in a way that brings science curriculum to life for the less enthusiastic.

Science educators in Ontario report that middle school students are consistently failing to grasp the ‘Big Ideas’ of the curriculum, emphasizing that the attained curriculum never quite matches the perceived intent (Turner and Peck, 2009). Based on what has been said about teacher and student-centered learning approaches, it may be suggested that students are failing to acquire enough procedural knowledge and are thus missing a large portion of overall content understanding, preventing them from developing more important big picture understandings.

Through more frequent implementation of SCL strategies such as PBL and LBD, teachers may better target these areas of curriculum disconnect, building students’ procedural understandings of scientific content, and perhaps promoting the development of more positive attitudes towards science learning. This study aims to gain insight from Ontario educators into this area in order to create a clearer picture of the situation at hand, get an up-close look at how this disconnect is being tackled by reported experts in the field, and draw from these experiences to promote increased implementation of SCL in Ontario science classrooms.

1.1 Purpose of Study

The purpose of this study is to investigate the ways in which educators currently employ SCL strategies in Ontario intermediate (Gr. 9-10) science classrooms to promote student engagement. I explore this topic by interviewing local TCDSB educators about: their understandings of SCL and experiences in implementing SCL strategies (with a focus on PBL and LBD) within the classroom setting; their self-confidence in employing SCL strategies; supports and barriers they experience with implementation of such strategies; and perceived results in terms of student engagement in PBL and LBD lessons. Findings will be shared with
the scientific and educational communities to further develop these strategies and maximize supports, overcome issues experienced in implementation of SCL, and promote its use within all educational contexts. It should be noted that SCL will be used throughout as somewhat of an umbrella term to describe student-centered approaches in general, while PBL and LBD will be used more specifically to refer to instances of SCL implementation.

It is the intent of this study that, with increased awareness and availability of SCL strategies in the Ontario teaching community, levels of student interest and success in the sciences will increase, inspiring the pursuit of higher levels of science education. Even without this pursuit of higher education, developing young citizens with a heightened awareness of environmental stewardship, increased capacity for technological finesse, and some basic understanding of life science should be a province-wide priority in Ontario. If we hope to continue cultivating analytical, creative, and socially conscious citizens, the promotion of practices that heighten student engagement in the sciences is of incredibly high importance.

1.2 Research Questions

Guiding my inquiry is the central research question: *In what ways are Ontario teachers planning and using student-centered learning (SCL) strategies such as PBL and LBD to deliver curriculum and promote student engagement in the intermediate science classroom?* Secondary questions designed to support my guiding query include:

- What are educators’ understandings and opinions of SCL as a valuable instructional approach?

- How comfortable are educators in employing PBL (and other similar student-centered learning strategies) in the classroom?
• What kinds of barriers and supports do educators experience when planning and implementing these strategies?

• What are educators’ observations of student responses to PBL/LBD with respect to classroom engagement?

1.3 Position of the Researcher

Turning complex scientific ideas into tangible concepts is an undertaking I have always found both intensely challenging and wildly gratifying. I am a straight-identifying white female, who was fortunate enough to have been raised in a comfortable upper-middle class home with incredible parents. I was extremely fortunate in my schooling as well, attending a small independent Catholic high school from grade 9-12 where I flourished academically under the supervision of science teachers who were passionate about their subjects. With a strong fascination for the life sciences and the phenomenon that is the human body, I found the most success learning under teachers who were flexible and innovative in both their delivery and assessment of the material. I am a highly visual and tactile learner and struggled with concepts where imagery and interactive stimuli were lacking. In my university education, I continued to explore science but was frequently disheartened by the amount of reading and memorization involved. I found myself frustrated with the system of note taking and memorization of concepts that often appeared to bear no connection to my own reality.

I discovered during my undergraduate studies that I had the power to enhance my learning by taking the lecture material and applying it in a way that suited my personal strengths. This is when I began to draw out my notes, creating doodles, using colour, and creating visual sequences to help me study. Doing this I discovered my passion: working to develop visual interpretations of scientific concepts to provide students, like myself, with high-quality
educational resources. I decided to pursue a certificate in Studio Arts at Seneca College to gain credibility and develop my artistic skill, with the end goal of applying my strengths towards the development of a more interactive science education.

Upon entering the world of education, I have made it my mission to make science accessible and (more importantly) enjoyable for all learning styles. In my own research, I hope to gain insights from educators who employ strategies such as PBL in the classroom regularly. I am confident that my research will provide both new and experienced educators the concrete support and pedagogical resources they require to effectively implement PBL strategies for successful delivery of the Ontario Science curriculum in the intermediate classroom.

1.4 Overview of the MTRP

To respond to the research questions, I have conducted a qualitative research study using purposeful sampling to interview three teachers about their experiences employing student centered learning strategies in Grade 9 and 10 science classrooms. In Chapter 2, I review the literature in the areas of scientific education, current PBL strategies, and educator reports on implementation of these strategies. In Chapter 3, I elaborate on the research design and methodology. In Chapter 4, I report my research findings and discuss their significance in light of the existing research literature. Finally, in Chapter 5, I identify the implications of the research findings for my own teacher identity and practice, and for the educational research community more broadly. I will also articulate a series of questions raised by the research findings and point to areas for future research and teacher development.
Chapter 2: Literature Review

2.0 Introduction

In this literature review, I will be reviewing literature on three major areas pertaining to the diversification of science education pedagogies in Ontario at the intermediate level. First, I review key studies on student disengagement from science education and explore factors contributing to its persistence. An important theme carried throughout this section is the apparent and growing need for re-shaping student affect towards science education. Next, I review the literature pertaining to student centered learning (SCL) with a directed focus on problem-based learning (PBL) and related student-centered learning strategies designed to promote positive affect towards science learning, both generally and within the contexts of intermediate science education. Finally, educator reports of personal experience with PBL with regards to motivations, barriers, and supports are reviewed and contrasted against more traditional science teaching methods. This literature provides valuable insight into the physical practice of implementing PBL in the intermediate science classroom. Content analyzed includes both national and international sources with a primary focus on Canadian studies.

2.1. Student Engagement in the Intermediate Science Classroom

Learning in any subject area begins with a sense of curiosity and is guided by quality of stimulation. When not innate, it then becomes the educator’s job to cultivate interest and curiosity, and to galvanize and encourage quality stimulation in order to provide students with a sound foundation upon which their educational journey is built. Student interest and engagement in school sciences is an issue leaders in education across the globe have grappled with for many years (Osborne et al., 2003; Barmby, Kind, & Jones, 2008). The ROSE Project, introduced in Chapter 1, represents a collaborative approach to investigating this issue and produced some
important findings with implications for future action to promote student interest (Schreiner & Sjoberg, 2004; Sjoberg & Schreiner, 2010). Targeting 15-year old students in over forty participating countries, this study provides the perfect springboard into the literature review because it found a lack of positive affect directed towards science learning in the intermediate grade levels. Armed with a new understanding of student affect and interests, action can then be taken towards re-shaping student attitudes in order to foster a growing society of rational, creative, and innovative thinkers.

When the goal is to improve student-reported attitudes towards school science learning, Osborne et al. (2003) found the importance of identifying the underlying sources contributing to this lack of interest. In the following section, external factors such as gender, culture, and socioeconomic status (SES) are suggested to bear some influence on student affect towards science education.

2.1.1 Gender

As with any study into the attitudes of a population, there exists a wide variety of variables that must be acknowledged prior to reaching conclusions. One such variable with reported influence on student engagement in the classroom appears to be gender, where females have been found to express negative affect (including both disinterest and anxiety) towards science learning compared to males (Catsambis, 1995; Desy, Peterson, & Brockman, 2011; Haladyna & Shaughnessy, 1982). This negative affect, however, does not appear to translate to female academic achievement in the sciences (Catsambis, 1995; VanLeuvan & McDowell, 2000; Weignburgh, 1995). Educational statistics presented by the U.S. Department of Education in 2007 revealed that females in fact present with slightly higher marks than males in most high school science classrooms, and are earning roughly the same amount of credits in the subject. To
contribute to the irony, Brockman et al. (2011) found that the majority of rural Minnesota high-school females surveyed in a study reported their intention to pursue a career in a science-related field.

Why is it then that we see such pronounced negative affect towards science learning in female students? In their exploration into student reports of engagement in high school science learning, Farenga and Joyce (1998) found that engagement in high school science is somewhat pre-determined by experiences had in elementary years. This reasoning is supported in an older study by Kahle and Lakes (1983) who identified elementary-aged girls as having significantly less exposure to opportunities for exploring and practicing science in real-world contexts such as field trips, social clubs, etc. They go on to explain how social constructs of the physical sciences being more masculine has also contributed to the dissuasion of females from the pursuit of science; the biological and health sciences (the latter being typically more female-dominated) are often forgotten as existing under the same heading (Kahle & Lakes, 1983). Even in more recent studies we continue to see that an element of gender inequality within the intermediate science classroom does indeed prevail; Bognar and Schumm (2016) highlight a significant decrease in female adolescents’ perceived self-efficacy in science learning compared to males of the same age (p. 444).

2.1.2 Culture

In 1984, Canada announced the need for the development of a science curriculum that would be effectively employed countrywide. Contrasting with the United States’ call for increased academic rigor, more frequent assessment, and raised admission standards for post-secondary education, the Science Council of Canada (1984) put out a report titled *Science for Every Student: Educating Canadians for Tomorrow’s World*. Identifying in detail eight major
initiatives, the main objective was to make high quality science learning accessible for all Canadian citizens (Leith, 1985). With Canada’s identity defined as a cultural mosaic, Every Student considers individuals from a wide range of cultures and SES. With this covering so much of our population, it is important to identify the range of effects these factors have on student engagement in the intermediate science classroom.

On a global level, the ROSE Project under Sjorberg and Schreiner (2010) found comparable differences in international student attitudes towards science education. One important finding was that students in wealthier nations view school science to be less interesting than other subjects, and are more likely to report a lack of excitement when it comes to new job opportunities within the sciences. This finding may come across as surprising, given that wealthier countries often have more educational resources to contribute to the innovative science education. One then wonders whether this disparity is a result of economic or cultural differences; in response, we turn to more local reports of cultural and socioeconomic factors influencing student engagement.

Research shows that attitudes towards science learning may vary across different ethnic groups, but this does not necessarily translate directly to predicting the achievement of these groups (Lee & Luyxk, 2013). The authors go on to discuss how developing educational tools that accommodate and fairly represent student values and cultural differences is no easy venture. That being said, culturally relevant science learning materials have been shown to produce higher levels of achievement within those classrooms (Aikenhead, 1997; Matthews & Smith, 1994). Additionally, Moje, Collazo, Carrillo, and Marx (2001) emphasize the need for educators to maintain an awareness of their students’ cultural identity in order to understand the ways in which each student approaches science learning.
2.1.3 Socioeconomic status

Though the following section speaks more generally about the interplay between SES and academic engagement and not necessarily at the direct level of intermediate science, the effect of SES on student engagement is an area worth investigating as it provides an alternative angle from which we may analyze the issue of reduced positive affect in science learning. Peng and Hill (1994) found that the student’s home environment can play a prominent role in determining student attitudes towards learning in all subjects. Parental attitudes specifically, are one of the strongest determinants of student attitudes, regardless of SES. In fact, students from low SES homes have been found more likely than their high-SES peers to demonstrate positive affect and excel in subject areas such as math and science when their parent(s) placed high value on academic achievement in these subjects, with parental knowledge not necessarily being a factor (Smith & Hausafus, 1998). What happens then, when parental support is removed from the equation?

In a rather large study of American secondary schools, Oakes (1990) found that in schools comprised of high minorities and low SESs, there were significantly less opportunities for science learning, decreased access to qualified teachers and resources for learning, and less emphasis on curriculum goals involving inquiry and problem-solving. A similar study conducted in Canada at the elementary level by Lee and Smith (1995) explored science achievement trends of Canadian students coming from lower SES (as cited in Ma, 2001). They identified two different classifications of school environments: “bureaucratic” and “communal” (Lee & Smith, 1995). In the study, bureaucratic schools were those that operated on a standardized set of rules with highly impersonal attitudes towards the teaching-learning relationship, whereas communal schools focused more on informal, interpersonal methods to
promoting student engagement in subject learning (Lee & Smith, 1995). They found that communal schools were more successful in narrowing the achievement gap between students of differing SESs. This finding supports the suggestion that that selective quality teaching strategies possess the capacity to overcome influences - such as low SES - in promoting student engagement in any classroom.

Evidently, student attitudes towards intermediate science learning is subject to a variety of interconnected extrinsic and intrinsic factors, including gender norms and perceived expectations, cultural values and beliefs, and socioeconomic influence at the level of the individual student. It is important to be aware of these contributing factors in order to address and control for each when exploring and implementing instructional strategies to work towards increasing positive attitudes towards science learning. In the following section I explore and discuss in greater detail the specific strategies designed to target the issue of decreased engagement in intermediate science classes in Ontario.

2.2 Student-Centered Learning (SCL) and Problem-Based Learning (PBL)

Despite the array of external influences on intermediate-aged student attitudes towards classroom science learning, quality teaching has proven time and time again to be a powerful antidote for rescuing even the most resistant of learners. Student-centered learning (SCL) is previously defined in Chapter 1 as a learning style fostering the acquisition of both declarative and procedural learning (Odom, Stoddard, & La Nasa, 2007). Researchers in this field advocate for it’s widespread application in science classrooms as a means of increasing student interest, promoting social interaction, fostering critical thinking, and developing applicable and transferable skills moving forward (Bell & Odom, 2015). It is the focus of this next section to provide the reader with a comprehensive understanding of PBL – an example of one SCL
strategy that has found significant success in the classroom. Highlighted throughout are some of the observed effects of employing this strategy in the intermediate science classroom.

2.2.1 Background and goals of PBL

Dating back to the early 1900s, case-based and project-based learning laid the foundations for a learning style that would be rooted in “meaningful tasks” (Dewey, 1938; Kilpatrick, 1918). As briefly identified in Chapter 1, problem-based learning is a Canadian invention and a constructivist-based model for learning developed originally for medical students as a means of engaging with the material as if they were already working in the field (Barrows, Tamblyn, 1980). With regards to the workings of PBL in the classroom setting, Hmelo-Silver (2004) synthesizes the five main goals developed by Barrows and Kelson (1995), all of which are synonymous with the goals set out by the Ontario Science curriculum. PBL is designed to invite students to “construct an extensive and flexible knowledge base; develop effective problem-solving skills; develop self-directed, lifelong learning skills; become effective collaborators; and become intrinsically motivated to learn” (Barrows & Kelson, 1995, as cited in Hmelo-Silver, 2004, p. 240).

Intrinsic motivation, as defined by Hmelo-Silver (2004), happens when personal interests, challenges, and feelings of satisfaction are the key guiding factors in a student’s learning. We see intrinsic motivation as an end result of PBL in an international study conducted in Hong Kong in the late 1990s. In effort to promote this motivation within a post-secondary setting, Chung and Chow (2004) created Subject Planning Teams (SPT) where students and teachers of the Hong Kong Polytechnic University worked together to design a student-centered curriculum for a natural science course. Tackling problems that were relevant to students’ reality yet adapted to fit within the curriculum requirements produced heightened levels of motivation.
for classroom science learning and developed a variety of important learning skills in researching, brainstorming, collaborative group work, and lateral thinking. In this example, we see the potential for promoting intrinsic motivation by using PBL strategies in the context of post-secondary science learning.

2.2.2 Intermediate context

Although PBL was initially intended for higher learning environments (i.e., university, college and post-graduate studies), PBL success stories are consistently found more frequently at the elementary and secondary levels. One such story can be found in High Tech Middle (HTM), a middle school based out of a diverse California neighbourhood. Lattimer and Riordan (2011) studied HTM and identified it as one of several locations where PBL has been effective in increasing student engagement in the classroom, as well as inspiring creative and receptive teaching practices. At HTM, teachers work to design problems that accommodate for the diversity of their students to engage their classrooms in “meaningful learning” (p.19). Using Steinburg’s (1997, as cited in Lattimer and Riordan, 2011) six elements of design, teachers at HTM ensure that every project assigned incorporates “academic rigor, authenticity, applied learning, active exploration, adult connections, and assessment practices” (p. 19). In following this layout, HTM teachers prevent PBL lessons from turning into “busy work”, an issue identified by Wiggins and McTighe (2005) that tends to occur when PBL is carried out improperly. From Lattimer and Riordan’s (2011) case study, we can observe clearly how educator understanding and degree of competence in employing PBL in the classroom is of high importance. Unfortunately, there is still much research to be done in the area of PBL in the intermediate setting, especially in a Canadian context (Goodnough & Nolan, 2008).
2.3 Educator Experiences of PBL Implementation

With so much autonomy over the curriculum, Day et al. (2007) propose that teacher motivation and effectiveness are largely determined by how teachers “work out – or fail to work out – the uncertainty and tensions in their professional lives” (as cited in Emo, 2015, p. 172). In a profession marked by constant uncertainty and second-guessing, the ways in which educators develop confidence and self-efficacy in their instructional approaches is a key area of interest in this study, and may provide insight into promoting a shift from more teacher-centered to student-centered instruction in intermediate science classrooms. The following section sheds light on the motivations reported by educators driving them to constantly improve and adapt their teaching practice.

2.3.1 Motivations

In an explanatory study conducted in the American Midwest, 30 teachers who teach in sessions ranging from elementary schools to universities were asked questions regarding their personal motivations in bringing innovative student-centered initiatives into their classroom. Participants of the study had self-identified as “innovators”, referring to innovating itself as introducing “fun” into their lessons, increasing “student ownership”, providing “applied activities”, and constantly evolving their material year after year (Emo, 2015, p. 182). Findings were drawn from personal interviews and demonstrate that motivations for innovation stemmed from both teachers’ professional and personal identities.

From a professional standpoint, Emo’s (2015) research revealed that teacher motivations for moving towards more student-centered instruction comprise perfecting their own teaching practice, improving their students’ learning environment, and promoting student engagement with the creation of applicable and memorable lesson plans. With respect to personal identities,
participants reported a desire to avoid boredom and monotony, personal preferences for change, and inspiration coming from their own children. All participants reported adequate pedagogical preparation in their pre-service teacher education, with continued learning taking place throughout their career.

A study (Prain & Waldrip, 2008) in Australian elementary and secondary schools involved interviews of eighteen educators on their use of multi-modal learning strategies in the science classroom. While not specifically identified as PBL, multi-modal teaching strategies are based on models of differentiation and student-centered learning, using different representations of subject material, and engaging individual interests to stimulate intrinsic motivation (Prain & Waldrip, 2008). The researchers found that educator perspectives on this type of learning were largely positive and, while sometimes difficult to implement, “cater[ed] very effectively for student diversity and [had] the potential to promote deeper learning” (p. 20). Participants of the study also advocated for making frequent and explicit connections between course content and the local community, largely agreeing that this type of instruction (multi-modal) provided a beneficial framework for the effective science teaching and learning practices (Prain & Waldrip, 2008). Evidence from this study serves to demonstrate how motivations for implementation of SCL strategies may outweigh barriers when teachers perceive their efforts as successful or valuable.

Remington High (pseudonym) in Toronto, Ontario embodies another example of this type of learning in a radical way (DeCoito, 2006). Founded in 1985, the school was run in a traditional manner marked by strict schedules and teacher-centered learning. After a radical change in philosophy in February of 1992, however, Remington High became recognized as a student-directed learning center where students make their own schedules and classrooms are
subject-based seminar rooms, stocked with resources specific to the subject content. Teachers at this school take on the role of facilitator of student-centered learning, consistent with PBL strategies. Qualitative interviews with three Remington High teachers revealed their belief in a constructivist approach to science learning, that science needs to be made relevant to the student’s reality in order to be most effectively taught, and that the social dimension to science education is not to be overlooked.

2.3.2 Barriers to PBL implementation

The following barriers refer to the different obstacles identified in the literature that interfered with teachers’ successful implementation of PBL in the classroom. Amongst all the positive feedback given in the interviews regarding the re-vamped educational system of Remington High (DeCoito, 2006), these teachers also reported some negative commentary with regards to their experiences implementing SCL strategies. Feedback indicated some uncertainty with regards to their role within the student-centered learning process, feelings of disempowerment, and insecurities about content knowledge. Habok and Nagy (2016) go on to highlight another negative outcome associated with SCL; it was found in their study that practices such as evaluation and discipline can often be lost with implementation of SCL strategies in the classroom. Questionnaires completed by over 100 teachers (elementary and secondary) revealed that as teachers become focused on motivation and transmission of values, they often experienced a decline in classroom management. An additional result demonstrated some confusion with regards to evaluation; this is mostly due to a lack of certainty in how assessment is to be structured within the context of PBL (Habok & Nagy, 2016).

Outside of these insecurities, Ertmer et al. (2009) – supported by a host of external sources (Gallagher, 1997; Kolodner, 2003; Kozma, 2003; Ward & Lee, 2002) discovered a
variety of common obstacles teachers may encounter before and during implementation of PBL strategies in their exploratory case study; such obstacles include planning time, lesson time constraints, assessment decisions, and the availability of technology. This is a general list of obstacles that certainly may not apply within every school context.

A quantitative study conducted in the American Southwest involved an analysis of in-service teacher perspectives on the purpose and efficacy of PBL in K-12 classrooms. Survey data revealed that although most participants were aware of PBL as an instructional strategy, many appeared to be unsure of the methodology behind the practice itself (Hovey & Ferguson, 2014). In addition, many respondents described the purpose of PBL to be creating projects, a definition not exactly aligned with the true objective of PBL – in fact, the study found that while most participants acknowledged PBL as being an effective instructional strategy, “many practitioners [lacked] a clear understanding of PBL methodology” (p. 85). Finally (and arguably most importantly), the majority of participants were in agreement that more professional development in the area of PBL was needed for both educators and administrators.

2.3.3 Supports for PBL implementation

The supports highlighted in this section are different strategies or experiences found in the literature that assisted teachers in their successful implementation of PBL. Strategies to combat teacher apprehensiveness towards using PBL in their classroom are suggested in Ertmer et al.’s (2009) study introduced above, in which five middle-school teachers from the American Mid-West were interviewed on their experiences with technology-driven PBL. With respect to the planning issue, these teachers identified backwards planning and using smaller inquiry units as ways to avoid becoming overwhelmed. In implementing PBL, teachers suggest adding more structure for struggling students, even going so far as to provide alternative projects. Holding
mini-lessons and providing web-links with external resources also proved to be helpful in the implementation of these activities. The most important point stressed by these teachers was the need for flexibility and the maintenance of a facilitator mindset. Despite all the issues identified in employing these strategies, all five teachers interviewed advocated for PBL, describing it as “a means to meet academic standards, foster interdisciplinary approaches, and engage students” (p. 47).

Professional learning communities were another way that teachers have found support for implementing PBL in their lessons, through fostering a sense of collegiality with their co-workers who shared similar desires to improve their own quality of teaching (Emo, 2015). Additionally, more than half of the respondents in Emo’s study indicated that their inspiration for implementing innovative practices came from formal professional learning experiences (professional development), most of which were personally funded. Harris, Roth, Assor, Kanat-Maymon and Kaplan (2007) found that teachers who demonstrated autonomous motivation for teaching promoted student autonomous motivation for learning; this is more evidence for the efficacy of modeling. Even further, these same teachers reported consistently providing choice and explaining relevance in topics covered, both practices shown to be necessary in the promotion of student engagement and intrinsic motivation.

Unfortunately, engaging the population of teachers who have structured their practice around traditional pedagogy is no easy venture. Pecore (2013) cites abundant literature finding that professional development rarely translates into improved teaching practices (Fishman, Mark, Best, & Tal, 2003; Walker, Recker, Robertshaw, & Osen, 2011; Wayne, Yoon, Zhu, Cronen, & Garet, 2008), emphasizing that teacher beliefs and opinions may act as predictors for change in practice, but are not often enacted in the classroom (Opfer & Pedder, 2011). It was also found
that teachers who were more open to change and reform were more likely to partake in more student-centered inquiry-based practice (Supovitz & Turner, 2000, as cited in Pecore, 2013). Opfer and Pedder (2011) “[suggest that] teachers’ beliefs and practices may change if provided with more and better opportunities for field and classroom experiences, reflection, challenging oneself in a safe environment, and applying knowledge about teaching and learning” (as cited in Pecore, 2013, p. 9). To effectively implement widespread change in instructional approaches, SCL must be at the forefront of every educational conversation or professional development workshop. In this way, educators may be presented with “more and better opportunities for field and classroom experiences”, engaging more closely with the tools and resources for SCL implementation in efforts to increase likelihood for instructional reform.

2.4 Conclusion

It is no surprise that promoting student engagement in the intermediate science classroom – a subject area so critical to the development of society – is an area that has been investigated quite thoroughly across the globe. In my review of the literature I have identified some of the major causes behind student disengagement in the sciences, including ideas surrounding gender norms, lack of cultural specificity, and gaps in socio-economic status. PBL was identified as having positive results in promoting both intrinsic motivation and meaningful learning for students. The concept of scientific inquiry was defined in light of its importance to the Ontario science curriculum, and a positive relationship between PBL and the goals of the curriculum in scientific inquiry was acknowledged. Finally, educator reports of personal experience employing PBL strategies and multi-modal learning techniques were analyzed. In these analyses, it was determined that in spite of the challenges associated with the implementation of PBL and other related strategies in the classroom, educators see benefits of PBL and student-
centered learning in promoting intrinsic motivation and student engagement. The literature indicates a consistent call for further inquiry on both teacher and student perspectives in relation to PBL, especially within a Canadian context.

In the following chapters I explore and analyze three individual cases of Ontario teachers and their personal experiences implementing PBL in their Grade 9 and 10 science classrooms as related to my research questions. In doing so I seek to begin to fill the gap in the literature, and provide some valuable insight into the ways in which the education community can effectively move towards a more student-centered teaching approach.
Chapter 3: Research Methodology

3.0 Introduction: Chapter Overview

This chapter aimed to identify and explain the methodological reasoning behind my data collection in investigating the key question: In what ways are Ontario secondary teachers planning and using student-centered learning strategies such as PBL to deliver curriculum and promote student engagement in the intermediate science classroom? Using a qualitative approach, I have postulated some important conclusions regarding the classroom implementation of PBL by grades 9 & 10 high school teachers, in efforts to target the issue of intermediate student disengagement in science learning. To begin, I provide insight into the research approach and procedures supplemented with supporting literature. Next, I describe the primary instrument of data collection (the semi-structured interview), detailing its effectiveness, and comparing alternative methodologies. Following this, I discuss the reasoning behind participant selection, sampling criteria, procedures, and individual participant biographies. I continue on to explain my methodology behind data analysis and review relevant ethical procedures. Finally, I identify the limitations and strengths of my chosen methodologies.

3.1 Research Approach & Procedures

My investigation into educators’ experiences surrounding the implementation of SCL and PBL in the intermediate science classroom was conducted using a qualitative research approach, involving both a review of relevant literature, as well as several semi-structured interviews with selected participants. As described by Patton (2015) the nature of qualitative research is personal, centered on the “[illumination] of meanings and how humans engage in meaning making – in essence, making sense of the world” (p. 6). Developing a deeper understanding of teachers’ perspectives concerning their personal practice in promoting student centered learning
was the aim of this study; not to quantify parameters of teacher success and failure in their implementation of PBL. Additionally, it is not in the interest of this study to make generalizations about the field of education and the individuals who play a role in it – an outcome commonly associated with quantitative research (Hesse-Biber & Leavy, 2004). A depth of knowledge in a localized area, with focused attention to specific cases, enables the researcher’s ability to “enhance data”, a defining trait of qualitative research (Ragin, 1994 as cited in Hesse-Biber & Leavy, 2004, p. 9).

Patton (2015) identifies the different epistemologies that may arise from qualitative research, each of which bears direct significance to the aims identified in my research questions: understanding the reasoning and consequences behind functioning systems, identifying consequences, understanding contexts, and using comparisons across cases to uncover patterns. Through qualitative analysis of interview data, this study worked toward a deeper understanding of the reasoning behind teachers’ decisions involving the implementation of PBL in their classrooms, observed consequential student responses, the contexts in which teachers are enacting these decisions (barriers and supports), and the patterns that emerge across participant explanations.

3.2 Instruments of Data Collection

The primary instrument of data collection for this study was a face-to-face semi-structured interview protocol, outlined in Appendix B. Gerson (2002) describes interviews as “[providing] the opportunity to examine how large-scale social transformations are experienced, interpreted, and ultimately shaped by the responses of strategic social actors” (p. 201). The semi-structured interview protocol is designed to gain insight into the mechanism behind social transformations in science teaching. My role as interviewer was an active one, as Corbin and
Strauss (2008) explain, “[a]sking questions enables the researcher to probe, develop provisional answers, think outside the box, and become acquainted with the data” (p. 69). Therefore, the instrument chosen was ideal for maximizing the acquisition of rich and relevant data.

Pragmatically speaking, the semi-structured interview may be defined as the middle-ground between a structured interview and an interview schedule (Jackson & Verberg, 2007). The semi-structured interview possesses most of the characteristics of a classic structured interview (e.g., set questions, allowances for prompts), while providing more opportunity for open dialogue, though not to the extent of the interview schedule where only the major ideas are prepared in advance (Jackson & Verberg, 2007, p.118). The utilization of the semi-structured interview allowed for significant exploration into the topic, while still providing structure and space for open dialogue.

This study may be classified as phenomenological in nature, as it “[sought] to achieve a deep understanding of the phenomenon being studied through a rigorous, systematic examination” (Jackson & Verberg, 2007, p. 161). Creswell (2007) explains the phenomenological approach as a key player in educational research, with the purpose of gaining a thorough understanding of participants’ personal experience. The interview protocol layout was designed to accomplish this particular goal. The protocol encompasses the participant’s entire experience, flowing systematically from the understanding of their general perspectives on student centered learning, to specifics on personal experience with PBL implementation, culminating in their observed/perceived results. The central research question and sub-questions provided the framework upon which the associated questions and prompts are built. In this way, continuous conversation was enabled, transitions were smooth from one focus area to another, and clear prompts elicited fruitful responses.
3.3 Participants

In this section I discuss the methodologies behind participant selection. I first provide an explanation of the sampling criteria, elaborating on the reasons behind each criterion. Next I discuss the sampling procedures, highlighting relevant literature to support reasoning behind the selection of these procedures. Finally, the biographies of each participant are described to provide a more comprehensive background for the research findings discussed in Chapter 4.

3.3.1 Sampling criteria

Due to the specific nature of this study, there are several sampling criteria that are necessary in order to extract information that is both relevant and useful. First, educators must have been currently employed in grades 9 and/or 10 science classes in Ontario, or have recent experience (last five years or less). To offer a balanced representation of upper intermediate grades, participants were selected evenly from both parties. This research is focused specifically on what is happening now in today’s student-centered era and current classroom practice, and less on out-dated perspectives. As such, finding current or nearly current teachers in a selected demographic of Ontario science education was vital to my study.

Participant’s location of relevant experience was another important factor of sampling criteria (i.e., school board, public school, private school, middle school, secondary school, alternative ed., etc.). Selected participants were all currently employed by publicly funded secondary schools within the Toronto Catholic District School Board (TCDSB). Having participants from similar demographics helped to equalize parameters such as classroom sizes and student population, allowing for a greater depth of focus on individual teacher perspectives and greater potential for cross-case comparison.
Selected teachers self-identified as being familiar with concepts of SCL and having implemented PBL – or some similar based student-centered learning strategies – in the intermediate science classroom at some point in their career. This sampling criterion was of utmost importance, as the central purpose of this study was to analyze and understand teachers’ personal experiences surrounding student-centered instruction and implementation of PBL. A large majority of the interview protocol focused on educator reports of personal experience implementing these strategies rather than be based on opinions and observations of others; having teachers lacking this direct experience would be an injustice to the study.

The selection criteria highlighted above serves to support the purpose of this study, which was to gather expert advice and provide both new and experienced educators with the support and resources they require to successfully implement SCL strategies like PBL, with the intent of fostering heightened student engagement in the intermediate science classroom.

3.3.2 Sampling procedures

Decisions involving sampling procedures play a vital role in expressing “who and what matters as data” to the research community (Freeman, 2000 as cited in Reybold et al., 2013, p. 700). Morse (1991) insists that without the strict guidelines identifying the selection process for sample subjects, qualitative research becomes diluted and quite confusing (as cited in Coyne, 1997, p. 623). Reybold et al. (2013) identify the process of participant selection as a product of subjective focus, quality procedure, and integrative method (p. 701-702). Based on the criteria outlined in the previous section, the most logical procedure for locating appropriate participants for this study proved to be criterion sampling. This is a form of purposeful sampling and involves the choosing of participants based on specific criteria such as their knowledge and level of experience in relation to the topic in question (Creswell, 2011, as cited in Palinkas et al.,
2015), and is demonstrated in the literature to be highly beneficial for acquiring a great amount of data using limited resources (Patton, 2002, as cited in Palinkas et al., 2015).

As identified by Palinkas et al. (2015), this particular form of purposeful sampling is based on similarities across sample subjects, rather than targeting differences between subjects. This type of sampling is similar in nature to snowball sampling, homogenous sampling, or typical case sampling, where the primary force in sampling is similarity across subjects (Palinkas et al., 2015). Theoretical sampling falls in this grouping as well, though it is mainly utilized in grounded theory studies (Coyne, 1997, p. 629). The criterion sampling procedure best suited the needs of this study in selecting the appropriate participants. Opposite of these types of procedures include critical case sampling, or theory-based sampling, where identification of variation in subjects is of high importance, and unsuited for selecting suitable participants.

Another procedure outside of the purposeful sampling umbrella is convenience sampling. This type of sampling is based solely on the situation of the researcher and what participants are most convenient to them, and is suggested to be largely useless in qualitative research (Palinkas et al., 2015). The sampling procedures of this study were not intended to be wholly convenient, however, as a current student of OISE constantly surrounded by professionals in the field, there was some element of convenience as I made use of my existing networks in the search for criterion-relevant participants.

3.3.3. Participant bios

In the following section I introduce and define my research participants, providing some insight into their personal experience and respective journeys in education. This section serves to supplement my Chapter 4 as it allows the reader to create a more holistic understanding of the mind-sets of my participants as represented in their interview responses.
My first participant, **Simon**, was referred to me by a friend who had Simon as their Grade 12 Biology teacher. Simon had been teaching for nine years with TCDSB at the same school. His schedule over the years has consisted of mostly intermediate (Gr. 9/10) general science classes, with the odd intermediate math, geography, and senior biology (Gr. 11/12). His teacher training had been completed in Ontario and he expressed his familiarity with SCL and PBL as stemming from his initial teacher training. When asked about why he had chosen to pursue science in university he insisted that he had known science would be his favourite subject since he was five years old and was first inspired by his fifth grade teacher who had his class partake in a PBL-type activity. He felt that science was marked by a need for creativity that other people sometimes didn’t see, and advocated for instilling that sense of wonder and intrigue in his students through his practice.

**Raymond** was referred to me by a friend who happened to be a former colleague of his. Raymond can be described similarly to Simon, very young and energetic, and clearly passionate about his chosen career path. Raymond had been teaching with the TCDSB for only six years as a permanent teacher – prior to that he completed his teacher education outside of Toronto where he was a student teacher for a different school board. He reported having taught courses other than science in his first year at his current school, but moved into science the following year teaching across intermediate and senior grades 9-12 for the following years. Raymond’s undergraduate background is also in science, with biology and chemistry serving as his two teachable subjects. When asked about why he decided to pursue education, his story was quite different that Simon’s – Raymond never thought teaching would be his path growing up as he reported a strong dislike for public speaking. It wasn’t until he took a position as an instructor for a children’s science camp in his second year of university and discovered how much he
enjoyed it. Raymond’s exposure to concepts of SCL and PBL also stem from his teacher education program, and he works to implement these concepts through ensuring that every lesson or concept taught in his classes possesses some sort of “buy-in” or personal investment for his students.

My third participant, Maryanne, was referred to me by an acquaintance who insisted I get in contact with “the best high school science teacher [she] ever had”. Unlike Simon and Raymond, Maryanne had over twenty years of teaching experience with the TCDSB. She reported teaching Grade 10 science every year, and Grade 9 maybe once over the twenty-plus years total, with a mixture of Grade 11 and 12 biology and physics classes sprinkled throughout. Her undergraduate background was also in science (biology and chemistry are her teachable subjects), but unlike her counterparts, she reported to have despised the subject throughout her entire university career. Maryanne framed her thinking as an intermediate student as being so focused on grades and societal norms that she pursued science simply because she performed well and felt that she was smart, and that studying science is just what smart people did. Teaching ended up being a career she simply felt she could get a job in with her educational background, as she did not want to continue with her studies into medical school or work in research. Once in the profession, Maryanne advocated for promoting active learning, rather than perpetuate the cycle of memorization and regurgitation of content, as she had done in her high school and undergraduate years. Maryanne ended up being a particularly interesting participant as her responses throughout the interview provided some great insight on the workings of SCL and PBL from an educator with a great deal of teaching experience.

I was very fortunate in my participant selection to have access to such a diversity of attitudes and experiences. In the following section I describe the process of data analysis
employed in order to extract valuable information and produce insightful findings from my participant responses.

3.4 Data Analysis

The process of data analysis as described by Denzin (1989) is creative, rather than mechanical, in nature (as cited in Esterberg, 1999, p. 152). The job of the researcher is not defined by their ability to “uncover” information supposedly hidden in each interview response, but to instead “create” meaning with the materials provided (Esterberg, 1999, p. 152). Emerson, Fretz, and Shaw (1995) explain that

[t]he ultimate goal is to produce a coherent, focused analysis of some aspect of the social life that has been observed and recorded, an analysis that is comprehensible to readers who are not directly acquainted with the social world at issue. (p. 142, as cited in Esterberg, 1999, p. 151)

Different types of analysis tools were explored and then carefully selected for the reasons outlined below, in order to produce a comprehensive analysis on teacher perspectives of PBL implementation in the intermediate science classroom.

Bernard and Ryan (2010) identify five key events marking the path towards effective data analysis. These include “discovering themes and subthemes; describing the core and peripheral elements of themes; building hierarchies of themes or codebooks; applying themes – that is attaching them to chunks of actual text; and linking themes into theoretical models” (p. 54). To begin data analysis, the discovery of themes from interview responses took place during transcription, post-interview. All materials were handled electronically.

Emergent coding was the procedure of choice for this study, marked by the creation of codes (relevant groupings of information) based on trends that arise from the data itself; this is
different from *a priori* coding, where codes are created prior to data collection based on certain theoretical constructs or previous research (Stuckey, 2015, p. 7). Emergent coding best suits the needs of this study as it provided a greater potential for the discovery of key similarities and differences specifically relevant to my research questions. Null data, or topics that interviewees could not or chose not to speak to, also played an important role in my data analysis, as hypothetical conclusions were sometimes drawn from a lack of information.

### 3.5 Ethical Review Procedures

The potential for ethical issues to arise in qualitative research – both at a personal and professional level – results primarily from the researcher’s face-to-face interaction with their human subjects, followed by the interpretive nature of qualitative data analyses (Soltis, 1989, p. 127). Sieber (2009) explains that

> [t]he ethics of social and behavioural research is about creating a mutually respectful, win-win relationship in which important and useful knowledge is sought, participants are pleased to respond candidly, valid results are obtained, and the community considers the conclusions constructive. (p. 106)

It was an ongoing priority of this study to maintain a critical awareness of the rights and freedoms of both the participants and the researcher, including: the protection of participant confidentiality and a requirement for consent, ensuring participants’ awareness of their on-going right to withdraw from the study, making known the risks of participation, and appropriate storage of recorded/transcribed data.

To protect confidentiality, participants have been assigned a pseudonym and their identities remain undisclosed, including the exclusion of any identifying markers related to their schools or students. This study is classified as “minimal risk” by the Canadian Tri-Council
Ethics Review Board as a (Canadian Institute of Health Research, 2010, p. 23); given the research topic, it is possible that a particular question may trigger an emotional response from a participant, potentially creating a vulnerable environment. I aimed to minimize this risk by reassuring them throughout the interview (and in the consent letter) that they possessed the right to refrain from answering any question that they may not have felt comfortable with, as well as re-stating their right to withdraw from participation. Participants were provided the opportunity to request a review of the transcripts and to clarify/amend or retract any statements before I conducted data analysis. Participants were made aware that all data (audio recordings) was stored on a password-protected computer – and was to be destroyed after 5 years. Finally, participants were asked to sign a consent letter (Appendix A), consenting to be interviewed as well as audio-recorded. This consent letter restates many of the assertions made above, as well as provides an overview of the study, addresses ethical implications, and specifies expectations of participation.

Protecting participants while still managing to extract rich and relevant data is an obstacle, or so Doucet and Mauthner (2002) suggest, as they emphasize the importance of maintaining authentic and stable relationships with subjects, while remembering there also exists a relationship between the researcher and the research community who will be exposed to and (hopefully) accepting of your claims (p. 124). To accommodate for both, authors recommend maintaining a high level of accountability or transparency throughout the course of the study as an effective way of building these authentic relationships; this is accomplished most prominently through reflexivity on behalf of the researcher (Doucet & Mauthner, 2002, p. 125).

3.6 Methodological Limitations and Strengths

Every research study bears its own methodological limitations and strengths, giving research in any given field the ability to be constantly changed, re-tested, and/or disproved. This
particular study into educator experiences with PBL in intermediate science learning was limited by several key factors, most of which are regulated by the parameters set out by OISE and the University of Toronto. Due to limitations in ethical approval from the university, data collection via interviewing was only to be conducted at the level of the teacher. It would have been of great use to my research topic to be able to communicate directly with students, as one of the overarching purposes is to discover ways in which science education can be tailored to promote higher levels of student engagement. It would also have been beneficial to be able to collect some observational data via ethnography, as interviewees may intentionally and/or unintentionally present bias and/or inaccurate information (Walford, 2007, as cited in Roulston, 2010, p. X). Finally, due to time constraints, I was limited in sampling size and therefore the amount of data I was able to collect. Ergo, the findings I obtain from few semi-structured interviews may inform the topic at hand very specifically, but cannot generalize the experience of teachers in a broader sense.

Relevant strengths of the study design include a great capacity for obtaining rich, and highly specific information from participants. Using interviews as the primary data collection instrument allowed for topics to be explored in greater depth than through alternative methods, such as a survey or polling (Siedman, 2013 as cited in Dixon, 2015, p. 2067; Tierney & Dilly, 2002). In addition, interviewing participants allowed for the discovery of unanticipated information, as participant responses were not excessively restrictive. Having one-on-one conversation also created a welcoming and lower-risk environment for participants to express views that they may feel would not be well-received by members in a focus group setting, providing the researcher with more insight on information surrounding more sensitive subject areas (Morgan, 1998, as cited in Gill, Stewart, Treasure, & Chadwick, 2008, p. 293). Finally,
these interviews were not only informative for the researcher; speaking in-depthly about one’s practice and philosophies regarding the teaching and learning relationship is an opportunity for teachers themselves to grow and reflect, an opportunity that may arise infrequently for some individuals (Calderhead & Gates, 1993; Ramsay, 2010; as cited in Williams & Grudnoff, 2011, p. 281).

3.7 Conclusion

In this chapter I have thoroughly outlined the research methodologies behind my study into Ontario educators’ experiences of implementing PBL into their grade 9 and 10 science classrooms. I have identified qualitative research as my chosen approach and explained the reasoning behind this decision using support from relevant literature. I then proceeded to describe the characteristics of a semi-structured interview in comparison against other forms of data collection, finally providing an explanation as to why this particular instrument was chosen for this study. In the following section I went into detail on my sampling criteria, using literature support to identify the reasons why these criteria are important to the validity of my study. I provided some insight on my chosen approach of purposeful criterion sampling, illustrating through comparisons to other related approaches why it was the most appropriate for my study in particular, and ended the section with participant biographies. Next, I touched upon the process of data analysis - again drawing on existing research to highlight the process of my decision-making, followed by a review of the ethical considerations made in the design process. Finally, I identified and explained key limitations and strengths of my methodological choices in light of my research purpose and questions. In Chapter 4 to follow, I report the findings of my research.
Chapter Four: Research Findings

4.0 Introduction

As illustrated in Chapters 1 and 2, student engagement in the intermediate science classroom is on a steady decline; research shows that despite consistent levels of high academic performance, intermediate-aged students are reporting disinterest in and a disconnection to the curriculum content (Barmby, Kind, & Jones, 2008; Osborne et al., 2003). The purpose of this study is to investigate the ways in which science educators are reportedly tackling this problem using student-centered learning strategies, with a special focus on problem-based learning (PBL) and learning-by-design (LBD, often also known as project-based learning). In this study PBL is considered an extension of student-centered learning; where student-centered learning is defined as a style of instruction in opposition to teacher-centered instruction, assigning more autonomy and personal choice to the student in their pursuit of subject content, PBL and LBD are specific strategies teachers may employ to help set-up and facilitate student centered learning. In the search for answers to my research question – in what ways are Ontario teachers planning and using student-centered learning strategies such as PBL and LBD to deliver curriculum and promote student engagement in the intermediate science classroom? – I have conducted semi-structured interviews with three Ontario science educators at three different TCDSB secondary schools, all of who have taught (or are currently teaching) at least one section of Grade 9 and/or 10 Science. In this chapter, I will present my findings as they relate to my research questions, drawing upon existing literature to supplement discussion. The findings are organized under four main themes:

1. Reported understandings of student-centered learning
2. The importance of developing lifelong learners
3. Perceived student attitudes and engagement in science learning

4. Implementation of student-centered strategies: PBL & LBD

The discussion within each theme section will draw from both research findings and existing literature to synthesize new understandings and determine where these understandings fit within the context of research in science education. In the conclusion section I will reiterate my key findings and transition to the final chapter.

4.1 Reported Understandings of Student-Centered Learning

When asked to define the concept of student-centered learning, I anticipated a fair amount of consistency across the three participants, and so was very interested to discover that their perceptions were quite diverse. Exploring the intricacies of modeling student-centered learning practices in the classroom – found by Harris et al. (2007) to be key promoters of student engagement and autonomous motivation – was an area of interest for this paper. In asking for their personal definition of student-centered learning and PBL, my intent was to gain insight as to how my participants understood the concepts and gauge whether they felt it important to implement such strategies in their classroom versus more traditional teacher-centered methodologies. Identifying perceived areas of success and failure in the implementation of these strategies allows for further discussion into the ways in which student-centered learning may be better adapted for the future.

Raymond viewed student-centered learning as the collaboration between teacher and student on a quest for knowledge. He elaborated on this idea, explaining that he felt it important for students to understand that he as the teacher did not know everything, and that the learning process was more of a democracy rather than a dictatorship. This view fit in well with his stated philosophy of teaching, which was that of fostering respect in the classroom. Raymond
emphasized the importance of the initial and on-going “buy-in” for students, presenting the
subject matter in a way that students could identify personal connections and relevance, further
modeling respect as an educator for his students’ learning and personal development. The
concept of student-centered learning was initially introduced to him in teachers college and he
acknowledged the concept as a valuable strategy in promoting student engagement and fostering
success. Raymond’s perspectives on promoting student “ownership” of subject content align
closely with Aikenhead (1997) and Matthews & Smith’s (1994) findings that presenting
culturally relevant materials effectively promotes science learning within specific cultural
contexts. His democratic approach to teaching aligns with views expressed by participants of
Ertmer et al. (2009), who advocate for the effective implementation of student-centered
instruction as a means of meeting curriculum standards and promoting student engagement.

Simon’s definition of student-centered learning had less to do with involvement of the
teacher, and placed heavier accountability on the students to take responsibility for their own
learning. His explanation bore distinct similarity to the concept of self-regulation defined by
Zimmerman (2001) in section 4.1. He explains:

Student-centered learning is kind of like, directing them towards a goal but not really
showing them the route, [and] just helping them realize that you’ll get there, you’ll get
there on your own path. [And] you can try and build your lesson around getting towards
that goal.

Simon worked toward a high degree of self-regulation on the part of his students, encouraging
them to take risks, make mistakes, and engage in on-going reflection; in this way he is effectively
modeling Intellectual Risk Taking (IRT) (Beghetto, 2009). When asked about his personal
philosophy of teaching Simon also expressed the importance of students taking ownership of the
material, with the teacher’s duty being to present that material in a way that students would be motivated to take ownership: “it’s [the] teacher’s job to bring [the subject material] to life”. In sum, both Simon and Raymond emphasized the importance of drawing connections to students’ realities as a key component of student-centered learning, insisting throughout that this strategy – though not always easy to implement – is a valuable player in promoting student engagement and positive attitudes towards science learning.

While Raymond spoke of on-going student-teacher collaboration and Simon of increased student responsibility, Maryanne defined her understanding of student-centered learning more broadly, referring to the concept as more of an umbrella term for all learning done in schools.

Well, I would expect that all learning be student-centered, because the point of education is the focus should be on the student, what the student learns. ... In terms of the flipped classroom, and like, the student is the master of their own learning and they do their homework ahead of time and then their teacher [trails off] ... I can’t buy into it.

Maryanne continues on this note, explaining her view that this type of autonomic learning would require an unrealistic amount of planning, communication with parents, constant vigilance, and classroom management that she felt to be outside the scope of her duties. She emphasized that standing back as teacher-facilitator would be something that she, even after twenty-four years of teaching, would not be comfortable doing in a classroom setting. Maryanne’s perspective is mirrored by findings from DeCoito (2006) and Habok and Nagy (2016) where educators reported experiencing insecurities with self-identification, feelings of disempowerment, inconsistency in evaluation and discipline, and an overall loss of structure when employing student-centered strategies to teach course concepts. Her scepticism also align closely with the findings of Wiggins and McTighe (2005): that when student-centered strategies
such as PBL or LBD are employed in the classroom, there is potential for the work to become simple busy-work or go from “minds on to hands on”, putting an overwhelming onus on the teacher to keep their students on the right track and remain focused.

It was interesting to see the contrast between Maryanne’s philosophy of student-centered learning and that of the other participants; whereas Raymond and Simon spoke about student autonomy and providing choice, Maryanne advocated for detailed structure, insisting that students “want to know who’s in charge, what they have to do, what the structure is, and what the expectation is”. When it comes to defining and effectively implementing their personal understandings of student-centered learning in their science classrooms, it is open to speculation as to whether time and experience, fear of the unknown, or a plethora of other reasons shape the perspectives of these educators.

4.2 The Importance of Developing Lifelong Learners

Encouraging students to become “life-long learners” who are self-regulating, reflective, and constantly engaging in inquiry was a goal that all three participants emphasized working towards in their teaching practice. Self-regulated learning, as defined by Zimmerman (2001), is a finely-tuned combination of operational processes that includes motivation, metacognition, reflection, and active participation. In the field of science education, this definition would extend to involve an aptitude for inquiry. Given the value inherent in these processes defined in the literature and by participants, fostering ability for self-regulated learning should be a primary goal of any educator, in any subject area.

When asked to explain their philosophy of the teaching and learning relationship, Raymond elaborated on the importance of respect, for the self as a learner and the teacher as a key agent in learning. He expressed an appreciation for inquiry-based instruction,
acknowledging the value in having students explore topics that were of personal relevance in the science classroom, while admitting that at times he found it difficult to incorporate all of this into his lessons. He emphasized that “[in] terms of learning, we’re all there for the same thing. I’m a life-long learner, they should realize that they are lifelong learners as well.” This thinking aligns closely with DeCoito’s (2006) findings of teachers expressing the view that the social dimension of science education is not to be overlooked, emphasizing that science is best taught when student’s social realities are brought into the classroom. Raymond had been teaching for only six years, and it was evident that these terminologies (inquiry, student-centered learning, PBL, etc.) were both familiar and valued, and had been incorporated in the development of his teaching philosophy. He went on to report positive experiences in his own intermediate science education, stating that, “of all the teachers I remember I can pinpoint my science teachers pretty quickly”. It was evident that Raymond had felt supported by his teachers throughout his science education and that this support had helped shape the positive lens through which he viewed the subject and his student’s abilities.

In response to the question, “what is your favourite thing about teaching science?” Simon smiled enthusiastically, and explained how the fact that “science [was] all about making mistakes” and how “in every other subject we don’t learn as much from our mistakes as we do in science” made science teaching and learning particularly enjoyable. He went on to note that he loved how students would constantly bring up questions regarding scientific phenomenon they had come across on social media, the news, through conversations with friends, etc., demonstrating an on-going curiosity and a pursuit of lifelong learning. Like Raymond, Simon also reported a positive history of his own intermediate science education, asserting that the
connection between science and the arts was something that he worked to model in his classroom, as it was what drew him in as an arts student:

I knew from like grade five that science was going to be my subject that I enjoyed the most; a lot of people forget you have to be able to include creativity. A teacher gave us a similar task [to the Rube-Goldberg experiment] where we had to build a structure and from that I was always concerned with what were the rules and she’s just like, ‘There aren’t any, these are your parameters, work within that’ and I just loved that idea. I was always kind of an arts students growing up too; art was a passion for me, and so being able to solve science using that creativity incorporates both.

Simon also made an explicit connection between the presence of creativity in science and the nature of student-centered learning strategies such as PBL, emphasizing his view that PBL embodied the nature of science most accurately, as the best scientists were those who were able to creatively solve problems with limited resources. It was evident in the way he spoke about his teaching style and classroom practices that Simon seeks to model autonomous motivation for his students, a key practice in promoting student engagement and intrinsic motivation (Harris et al., 2007).

Maryanne also advocated for the importance of lifelong learning, and expressed autonomic motivation in teaching students “to learn how to learn”. Waeytans, Lens, and Vanderberghe (2002) investigate what exactly is meant when teachers use the phrase “learning how to learn”, imploring that the overuse of what may appear to be a valiant initiative may be detrimental to its success in an educative context. Maryanne defined her personal application of the concept to refer to “taking risks, [becoming] lifelong learners ... learning how to problem-solve, and learning how to strategize ‘about problem-solving in different contexts.’” When asked
to describe her philosophy and personal experience in more detail, Maryanne spoke less about the use of the inquiry as strategy to promote student success, and more about classroom management as a critical component to successful teaching. This response differed significantly from the other two participants, both of whom had defined “lifelong learning” as a concept centered more on fostering a sense of wonder, self-reflection, and a motivation for acquiring new knowledge.

When asked specifically about teaching science, Maryanne indicated that she did enjoy it, but not necessarily because of the subject or any specific curriculum content; rather, her enjoyment came more from the act of teaching on its own. As she explained, “I enjoy seeing the kids being excited by it, I think I would enjoy teaching anything”. She was also the lone participant who did not cite intermediate student science class experience as her stimulus for further studies. When asked about her own experiences she responded:

I liked whatever subject I did the best in, and whatever teacher I liked the most. ... I did well in anything, but I thought that if I was a really smart person I should go into science, because that would like, prove to the world how brilliant I was.

This perhaps elitist view of science is not something unique to Maryanne, and is an area of research that I believe warrants further exploration in educational research in terms of students’ and teachers’ motivation.

Though participants approached the concept from a slightly different angle, Raymond, Simon, and Maryanne each expressed the promotion of lifelong learning as being a primary goal in their teaching practices. One particular area of divergence is in the context in which the three participants presented their understandings of fostering lifelong learning; where Raymond and Simon referred more specifically to the value of inquiry-based learning to fostering curiosity in
the science classroom, Maryanne argued that classroom management in any subject area was the key proponent in teaching students to “learn how to learn”. In light of these findings, it is worthwhile noting the contrast among the three participants’ educational backgrounds and teaching experience. Both Raymond and Simon had graduated from a pre-service teaching program within the last ten years, whereas Maryanne had over twenty years of experience working in the classroom. Having been exposed to potentially different teaching philosophies in pre-service education compared to more recent programs, combined with a great deal of in-service experience, it is possible that Maryanne is a member of the population whom Pecore (2013) refers to as having structured their practice around more traditional, teacher-centered pedagogies.

4.3 Perceived Student Attitudes and Engagement in Science Learning

In the following theme section I will report on participant perceptions of student attitudes and engagement levels in their intermediate science classrooms. There was some exploration into the topic of risk-taking, as participants reported a significant trend: students’ marks focus hindering participants’ ability as teachers to foster more meaningful thinking and connection-making across scientific concepts. It is the intention of this section to analyse teacher perspectives on student engagement in science as it relates to their practice implementing student-centered learning strategies such as PBL and LBD.

All three participants reported high levels of student engagement in their classes, both throughout the year and specifically when implementing student-centered learning strategies (to be identified in more detail in section 4.1.2.). This was an unexpected finding, as the literature (e.g., Barmby, Kind, & Jones, 2008; Osborne et al., 2003) suggests an overall negative outlook on student engagement in science learning, stemming from factors including gender, culture, and
SES. The ROSE Project conducted in 2010 produced findings that positive affect towards science learning was lowest for intermediate-aged students in developed countries such as Canada and the USA, despite their appreciation for it’s value or high academic achievement in the subject area (Sjoberg & Schreiner, 2010). Based on my review of the literature in conjunction with my own research findings, it appears that student engagement in intermediate science education may be largely dependent on the quality of instruction and the strategies employed by educators that help students see themselves reflected in the curriculum content.

Raymond articulated that his lessons were most often met with enthusiasm and questions from his students, but that the level of enthusiasm and curiosity often depended on the ability level of the students in his class. He reported finding students in the academic (university) stream to be a lot more inquisitive and “much more willing to ask questions”, especially regarding content they encountered via social media. In terms of the applied and essential streams (college and work-force), Raymond emphasized the need for more hands-on learning than with the academic stream, and a constant element of motivation. He stated that one of the most difficult things about teaching science was keeping the students motivated when the content became difficult, and that inquiry-based tasks were often more difficult with the applied and essential classes as they seemed to exhibit less “ownership of the material” and less independence when it came to critical thinking. This was an interesting finding, as my understanding of the “applied” stream is to be much more focused on taking concepts and putting them into real-world context, defined as being one of the primary goals of PBL (Barrows & Tamblyn, 1980). The fact that Raymond indicated inquiry-based tasks being more difficult with these streams seems counter-intuitive. Chung and Chow (2004) found that providing problems that are highly relevant to students’ realities produces heightened motivation for
classroom science learning and develops a host of important investigative and communicative skill sets. Therefore, a question may be just how relevant the inquiry units truly were to students’ realities. If highly relevant, it is worth considering some other strategies teachers may enlist to provide additional support to students struggling with independence or initiative, without having to resort back to traditional teacher-centered pedagogies.

Simon shared similar sentiments when asked about his perceptions of student engagement, stating that his students were “for the most part pretty receptive” and that “they like what they’re learning”. He also claimed that “[a] lot of times they don’t really get what the point is because they’re so regimented into being told what to do”. This concept of being regimented and averse to risk-taking appears to be a recurring theme evident both in literature and across participant reports, with the potential of having detrimental effects on the application of student-centered pedagogical strategies in the classroom. Beghetto (2009) explains how engaging in tasks just above the level of one’s cognitive abilities is critical in the promotion of learning and cognitive development, two objectives closely tied to the generation of investigative skill sets fostered with the employment of student-centered strategies such as PBL and LBD (Kolodner et al., 2003).

Maryanne also expressed a lack of willingness for risk-taking to be an issue in her classes. When asked whether she had observed any changes in level of student engagement across her twenty plus years of experience, Maryanne responded:

I think that kids are as enthusiastic as they have ever been, I find that particularly since getting rid of OAC and kids are forced to do more courses in – or the same amount of courses in a shorter time, and there’s this idea that everyone must go to university, kids
have real lack of willingness to risk. So risk-taking has decreased and marks focus has increased and I attribute it to the loss of Grade 13.

Maryanne went on to emphasize that students (her intermediate-aged self included) were too focused on grades, hindering them from being able to see value in the content presented in any subject. She describes herself as a learner being completely marks-focused, only memorizing what was required to do well on the upcoming test, and then forgetting everything directly afterwards. This is not unlike a large majority of students across a variety of educational stages (Beghetto, 2009); intellectual risk-taking (IRT) is in short supply in schools, and is shown to decrease with age as marks-focus increases. This is unfortunate as higher frequency of IRT is shown to be positively correlated with an increase in “adaptive learning behaviours”, including the sharing of ideas, asking questions, and trying new things (Beghetto, 2009, p. 210). This evidence points to an imminent need for educational research targeting teacher understandings and proficiencies in increasing IRT in the classroom.

It appears in the analysis of these findings that further investigation into the application of student-centered learning and PBL/LBD as a means of promoting student affect may be warranted. Despite educator reports of high levels of engagement in their classes, there appears to be some confusion as to whether this engagement stems from initial student ability, specific framing of curricular content as inquiry units, or students’ perceived importance of evaluation. Implications of these findings and recommendations for ways to overcome issues in student engagement as related to student-centered learning, PBL/LBD, and IRT are further explored in Chapter 5.
4.4 Implementation of Student-Centered Strategies: PBL & LBD

All three participants appeared to demonstrate an understanding of the methodology of student-centered learning in their reportedly successful implementation of PBL and LBD, something that educators may often be unsure of, despite their general awareness of these strategies (Hovey & Ferguson, 2014). In the following theme section, I will report on data pertaining more specifically to PBL and LBD by describing several detailed examples provided by participants. I have designated a subtheme entitled Barriers and Supports to provide some further insight into the reported effects of these on the implementation of said strategies. It is my intention for this section to highlight some reported teacher practices and perceived outcomes in the area of PBL and LBD, providing both pre-service and in-service intermediate science educators with a starting point for their own application of such strategies in the classroom. It is important to note that no physical data was acquired to support any of these exemplars as being quantifiably “successful”; as such, I have chosen to use perceived levels of student engagement and positive external feedback received to serve as qualitative indicators of successful practices.

Participants all expressed a great deal of enthusiasm when asked about a time when they felt they had been successful in their implementation of PBL, reporting high levels of engagement from students and positive external feedback from parents and colleagues. Simon recalled a time where he taught Grade 9 electricity by having students build human circuits using mini-marshmallows as their energy source. The lesson was scaffold as a whole-class discussion of electricity and the mechanics of a circuit, supplemented with visual animations. This mini-lesson was then followed by a whole-class interactive display of a human circuit, and finally segued into the assignment of a small group project where students were responsible for designing and creating circuits with different parameters. In this way, Simon prepared his
students for the individual work so that when it came time to approach the problem of creating their own circuits, they would be well equipped for the task. Thus, Simon felt he was able to stand back and act as facilitator while his students problem-solved using their prior knowledge to come up with a functioning final product.

Participants of Ertmer et al’s (2009) study on middle-school teachers’ implementation of technology-based PBL report a facilitator mind-set as being one of the most crucial elements in effective PBL implementation. Simon’s example demonstrates his abilities to act in a facilitator role, and reveals his appreciation for the value of multi-modal teaching. This strategy, based on differentiation and student-centered learning, is reported by Prain and Waldrip (2008) to stimulate intrinsic motivation, engage individual interests and promote “deeper learning”.

Maryanne reports a different approach to PBL. Towards the beginning of her Grade 10 physics unit she administered an exceptionally difficult problem set to every student. It was a problem she had come up with herself to avoid students simply finding the answer on the Internet, and it required intricate knowledge of the subject content. Students were given the course of the unit to work on the problem set, with no set parameters – they could work in groups or individually, they could use a computer or any available resources, they could ask for help from parents, friends, etc. The only rule was that they could not ask Maryanne for any assistance and the problem set had to be completed by the end of the unit. In this way, Maryanne was able to scaffold her lessons to provide a slow reveal of clues and concepts that students could take and apply to their problem set, encouraging students to be attentive during class time, and promote critical thinking and connection-making across lesson concepts and questions asked in the problem set. In this example, Maryanne demonstrates how she uses backwards planning and smaller inquiry units in the form of a problem set in her implementation of PBL. This strategy
has been shown to be effective in minimizing the feeling of being overwhelmed, a feeling often experienced by educators in these situations (Ertmer et al., 2009).

Raymond reported success in implementing LBD in the form of a cumulative rollercoaster project. The project, which spanned a period of two and a half months, was described as follows:

[Essentially], they were given a hand-out that said they were a design and engineering team for Canada’s Wonderland and they had to create a free-standing roller coaster. It had to be of certain dimensions, and it had to incorporate an initial drop, a loop, a corkscrew, a turn on a banked angle, and the marble [their cart] had to be on the track at all times. They were allowed to use whatever materials they wanted to, and they were given $40.

Raymond continued to explain the necessary requirements for application of curriculum content knowledge. They had to apply formulas, definitions, and calculations acquired over the course of the unit and keep a running record of their progress. He reported a great deal of enthusiasm from the majority of students, with the odd exceptions being those who either found the content too difficult and were overwhelmed, or those who did not work well with their fellow group members.

The above reports serve as a small sample of ways that teachers can incorporate student-centered learning into their science classroom. Scaffolding, backwards design, and student-led research were all described by participants as important in the smooth implementation of PBL and LBD. In the following section, participants demonstrate their ability to make use of these strategies and others to overcome barriers identified in research; all to provide relevant, enjoyable, and accessible learning opportunities for students as a means of promoting student success and engagement in science learning.
4.4.1 Barriers and supports

All three participants reported areas where they felt PBL or LBD fell short in accomplishing certain curricular and/or developmental goals. Each participant expressed some concern with respect to time constraints imposed by the complexity of the Ontario science curriculum, indicating that with so much content to cover, it would be “absolutely impossible [to have a project-based course]” (Maryanne). Both Raymond and Simon acknowledged that teacher-centered instruction (lecturing) was a necessity of any course, stating that without it, “you’d never finish the curriculum” (Simon), but emphasized that they worked to keep their lecturing to a minimum while devoting more focus on inquiry and practical work. Maryanne posed several concerns about the application of PBL and LBD in her own intermediate science classroom, mostly having to do with her ability to maintain effective classroom management. She also expressed her frustration with the idea of play-based learning, another subset of student-centered learning strategies where students are invited to explore subject matter prior to receiving any specific knowledge or context. She articulated that without some sort of guide, giving Grade 10 students the opportunity to “just play” was a waste of time. These sentiments aligned with Habok and Nagy’s (2009) finding that discipline and evaluation can often be lost in these types of inquiry-based student-centered learning environments.

When asked to provide examples of supports, all three participants reported feeling well supported by their administration, and had received frequent positive feedback from both students and colleagues with respect to their practice. This finding was expected given my sampling criteria being based on seeking out science teachers who were referred to me by others as successful teachers. Raymond indicated a strong bond with his department members and praised his department head, explaining how “he [was] constantly encouraging [them] to work
together”. The significance of this collegial support for student-centered learning is supported by the findings of Emo (2015), identifying the importance of professional learning communities and describing how teachers may find motivation in developing their own practice by fostering collegiality with fellow colleagues who are equally motivated to improve their quality of instruction. Through sharing of resources and ideas via these professional learning communities, teachers may be more likely to take risks themselves in implementing strategies such as PBL and LBD. Raymond also described how taking “code days” was highly encouraged by administration, providing incentive for staff to work towards the constant evolution of subject material, enabling them to team-teach and make student-centered learning more accessible. Given the low SES demographic of Raymond’s school, this evidence allows for the conclusion that selective quality teaching strategies and a communal school environment possess the capacity to overcome external influences - such as low SES - in promoting student engagement in any classroom (Lee & Smith, 1995).

Another support unique to Raymond was community outreach via an initiative called “The Science Club”. The club was made up of an assortment of students from grades 9-12 who got together to practice demos and experiments, organize functions such as Grade 8 orientation night, and run science workshops for elementary aged students. The club brought in external revenue, which was used by the science department to purchase educational materials for science teaching; these included things like: model organisms, advanced measurement instruments, microscopes, etc. Despite the demographic, the science department’s availability of resources and quality of instruction was incredibly high. This finding diverged significantly from Oakes’ (1990) finding that in schools comprised of high minorities and low SESs, there were less
opportunities for science learning, decreased access to qualified teachers and resources for learning, and less emphasis on curriculum goals involving inquiry and problem-solving.

Simon and Maryanne reported less involvement with colleagues and administration, though not in a negative sense. To the question of whether there was any team teaching or collaboration in planning Simon responded, “We follow the same flow of information but what I like, and what I think, is that no teacher should be told how to teach it. [...] We all have very different styles and we all have different personalities so why would we all present it in the same way?” Maryanne reported a high amount of autonomy with respect to decisions regarding planning and implementation of the curriculum, stating that one’s quality of teaching should be independent of external factors such as funding or administration. She states, “[...] Even like bad administration, good administration, they didn’t really affect what I did in the classroom at all.” This autonomy is highlighted by Day, Sammons, Stobart, Kington, and Gu (2007) as the reason why self-efficacy and intrinsic motivation is so critical in the teaching profession, factors that are ultimately shaped by the ways in which teachers learn to cope with stresses and insecurities in both their personal and professional lives.

Despite some significant differences in philosophies and pedagogical approaches, all three participants presented a great deal of intrinsic motivation and self-efficacy in both their responses and mannerisms. In order to cultivate these types of attributes in students, it is important that educators are able to effectively model what self-efficacy and intrinsic motivation look like in the classroom.

4.5 Conclusion

As indicated in my introduction, the purpose of this study was to investigate the ways in which science educators are tackling the issue of reduced student engagement in science learning
using student-centered learning strategies. Four key themes emerged from the analysis. The first theme identified participants’ value of “lifelong learning” and its importance in promoting student engagement and inquiry in the intermediate science classroom. Participants expressed viewing themselves as lifelong learners and discussed their efforts in actively working to model and teach this skill of “learning to learn” to students in their practice. It was interesting to note the differences in participant definitions of the “learning to learn” concept, especially as literature presents this phrase as being somewhat vague and overused by many educators.

Next, I discussed participant perceptions of student engagement and attitudes towards science learning. Here I discovered a divergence from the literature claiming how student engagement in science was an issue to be remedied. Participants reported high levels of engagement from their students in all science classes, indicating issues with persistence and motivation over the course of the year. It was interesting to hear about reportedly less motivation in the applied stream, as applied sciences were intended to cater to science in more tangible contexts. A sub-theme highlighting the hesitancy of students to intellectual risk-taking (IRT) was identified in this section, and explored with supporting literature to reveal a lack of IRT as a hindrance to the development of lifelong learners.

The third theme discussed was the participants’ appreciation of the value of student-centered learning as a strategy to promote engagement in their intermediate science classes. Two of the three participants expressed great appreciation for this strategy, asserting that subject content should always be presented to the student in a relatable format, aligning with the extant literature advocating for educators to not ignore the social dimension of science learning. One participant expressed different views, reporting issues with student-centered instruction with respect to classroom management. These findings aligned with educator reports in the literature
identifying classroom management as a barrier in implementation of student-centered strategies such as PBL.

Finally, the fourth theme was laid out in such a way as to provide some direct insight into what exactly successful implementation of PBL and LBD looks like in the intermediate science classroom to educators. All participants reported positive experiences with implementation, receiving affirmative feedback from external sources including colleagues, administration, and students. The details of each participants’ implementation practice were provided to serve both as evidence and a valuable resource. A subtheme elaborating on the different types of barriers and supports identified by participants went on to show how a lack of professional development, a resistance to change, time management, and lack of confidence in a facilitator role were hindrances to more frequent implementation of PBL & LBD. Participants highlighted intracollegial support (professional learning communities), autonomy over curriculum, and supportive administration as key supports to implementation of PBL and LBD.

Through this enumeration of my findings, I have highlighted areas of success and areas for improvement in the advancement of teacher employment of student-centered learning strategies in the intermediate science classroom. I was surprised to find such a disparity in definitions and attributed values among participants, given my adherence to my sampling criteria. I believe it makes sense to highlight the difference in years of experience as being an underlying factor for these disparities; however, further research is required in this area in order to make any reliable claims. Regardless, an increase in professional development in the area of student-centered learning in science education is highly recommended, as it is indicated frequently in the literature that providing teachers with opportunities to learn more about the
methodologies of concepts may lead to more frequent implementation of these strategies. I will say more about this in the following chapter.

In the Chapter 5, I will elaborate on the broad implications of my findings as they pertain to Ontario teachers, administration, policy makers, and teacher education programs. Narrow implications will provide insight into my personal vision for my future practice. Finally, I will conclude with recommendations for the above-mentioned stakeholders for future practice, and highlight areas for further research.
Chapter Five: Conclusion

5.0 Introduction

In this final chapter I briefly summarize my key findings from my research study and highlight their significance as they pertain to my original research questions. I then go on to illustrate some of the broad implications of my findings and their effects on several different stakeholders in Ontario. I will follow with some narrow implications for my own future teaching practice, and make some professional recommendations for future educational practice. Finally, I will finish off the chapter by pointing to areas in which I believe further research and/or development is warranted.

5.1 Overview of Key Findings and Their Significance

In my investigation into teacher reports of student-centered learning and problem-based learning/learning by design (PBL/LBD) in the intermediate science classroom I unveiled several key findings, organized into four major themes in Chapter Four. The first theme, which dealt with teachers’ reported understandings of student-centered learning, revealed a discrepancy in participants’ definitions of the concept of student-centered learning (SCL). This divergence in conceptualization of SCL suggests several possible implications, of which I discuss further in the following section. Despite the variance in definition, all participants were found to acknowledge SCL as a term they had encountered before and regarded it as good pedagogy.

The second finding illustrated the perceived importance of the development of students as lifelong learners (both in and outside the science classroom) as a primary indicator of teacher success. All three participants indicated that modeling their own love for learning, appreciation for inquiry and risk-taking, and ability for self-regulation were means by which they actively promoted the development of their students as lifelong learners. Despite some discrepancies in
pedagogical approaches, all three participants reported an enthusiasm for their subject area and teaching in general, suggesting the (arguably likely) possibility that enthusiastic teachers may produce more enthusiastic learners.

Student engagement was a primary area of concern for this study as the literature indicates an epidemic of low positive affect towards science learning in the intermediate grades. This persists despite reports of high levels of academic achievement and student acknowledgement of science as a worthwhile area of study (Sjorberg & Schreiner, 2010). In response to questions about perceived student engagement in their respective Gr. 9 and 10 science classes, all participants reported levels of interest and engagement higher than expected based on the literature. Interestingly, teachers reported that students in the academic stream demonstrated increased curiosity and engaged more in inquiry-based tasks than those in the applied stream. I found this to be particularly curious, as it is the applied stream that is intended to focus on modifying abstract scientific concepts to fit more clearly into real-world contexts. Real-world application of curricular concepts is one of the primary goals of PBL and LBD, strategies designed to increase accessibility and promote student engagement, and so I had anticipated reports of higher levels of interest and engagement with application of SCL in applied stream science classes.

It was my intention in the final theme section to highlight some reported examples of teacher practices of PBL and LBD as specific strategies of SCL, and their perceived outcomes. All participants reported perceived successful implementation of these practices, with these perceptions based largely on their experiences of positive feedback from students and fellow colleagues/administration. Some common obstacles they identified included time-management, self-regulation, and a hesitancy to “get started”, tying into the idea of students’ lack of risk-
taking as a hindrance to effective student-centered instruction. All the above were found to align closely with participant reports in the literature. These findings will be further addressed in the implications section to follow.

5.2 Implications

The following section is divided into two sub-headings. In the first – broad implications – I provide some insight as to what the implications of my findings are for several important stakeholders in the educational research community: teachers, administrators, policy-makers, and pre-service education programs. In the second – narrow implications – I elaborate on implications for my own future practice and how these relate to my reflexive positioning as a white, educated female.

5.2.1 Broad implications: The educational research community

My research findings in the area of SCL in intermediate science classrooms in Ontario bear the largest implications for front-line staff in the field of education: teachers. As participants report an on-going trend of decreased willingness to take risks and make mistakes, it may be worth bringing to attention the issue of assessment. One implication may be that teachers are dedicating too much focus or projecting too much value on summative assessment. Participants reported students’ heavy marks focus as an area they struggled with when attempting to engage their students in inquiry and student-centered learning. This emphasis on summative assessment in the form of quizzes, unit tests, and exams in the science classroom may be taking away from the learning process and element of inquiry advocated for in the Ontario curriculum as a means of promoting lifelong learning.

A second implication for educators in the classroom may be a difficulty in finding balance between covering curriculum content and establishing effective learning strategies.
Participant reports aligned with research in expressing difficulty maintaining a facilitator mindset when implementing practices such as PBL and LBD, strategies that require increased student autonomy and self-regulation. Having insecurities in this area may result in teachers being less likely to relinquish control as is called for in SCL, and resorting back to more teacher-centered methods of instruction. This implication may further tie into the unanticipated finding of decreased student engagement in the applied versus academic streams mentioned earlier. Perhaps it is more an issue of classroom management relating to demographics and students’ previous experience that prevents educators from effectively employing SCL practices in applied science classes, or – an alternative possibility may be that it is the more abstract nature of academic stream content that lends itself better to fostering a sense of wonder and inquiry. In a similar vein to the former, participants also reported time constraints as a significant issue in meeting expectations of the science curriculum while engaging students in SCL on a more regular basis. This implication also applies to the policy-maker community, as it may be more an issue of an over-packed curriculum rather than teacher difficulties in finding this balance.

The issue of decreased risk-taking may fall also into the hands of the school administration. Principals and vice-principals may be placing too much pressure on teachers to have students achieve certain grades, or be taught in a certain manner so as to increase achievement in province-wide standardized tests. In this case, teachers may be more likely to reduce emphasis on formative assessment and the learning process as they feel pressured to meet certain quantitative expectations. Another implication stems from the finding that participants reported little exposure to professional development (PD) in student-centered learning in science. It may be the case that administrators are failing to provide appropriate incentives or opportunities to promote the acquisition of knowledge and building of confidence in this area. It
is important to note that responsibility also lies with the teacher to self-advocate for one’s on-going professional learning; therefore, this implication surrounding inadequate PD may be the fault of both teacher and administration.

Policymakers, specifically those involved in the writing and layout of the Ontario Gr. 9 and 10 Science curriculum documents, may be failing to achieve certain goals related to scientific inquiry and “science for all” in their in/exclusion of certain content and/or overall layout. Participants reported concerns with respect to time constraints imposed by the complexity of the science curriculum, stating that it would be “absolutely impossible [to have a project-based course]” and that teacher-directed instruction was a necessity in order to cover all curricular content. Another implication of policymakers is related to the lack of PD - there may simply not be enough of it mandated, or there may be an overall lack of available opportunities.

A final implication is for Ontario pre-service teacher education programs in which there may be either a lack of consistency in education surrounding SCL, or not enough time devoted towards exploration, practice, and development of strategies such as PBL and LBD. As stated prior, there was some divergence found in participants’ conceptualization of SCL, framing several potential implications. Perhaps the term itself (student-centered learning) is in fact too broad, requiring redefinition or at least clarification in order to become something teachers can actually see and use. As previously stated, the concept may be taught differently across different teacher education programs, highlighting inconsistencies in the pre-service teacher education system. A final possibility is that student-centered learning is a concept that is ultimately shaped by individual teacher experiences and may not be defined in general terms.

The broad implications illustrated above are all suggested associations between findings of this study and goings-on of specified parties of the greater educational research community.
In the following section I will highlight some implications these findings pose for my own professional practice.

5.2.2 Narrow implications: Professional identity and practice

Engaging in this research study has been extremely valuable to my personal development as a future science educator and teacher-researcher. The findings produced several implications for my future practice. First, I will make it a priority to advocate for my own professional learning (and consequently my students’ learning as well), modelling the passion for lifelong learning that participants reported to be so important. I will seek out PD opportunities, working towards expanding my SCL repertoire, and building the confidence and skill required to successfully maintain a facilitator mind-set. Along the same line I will advocate for time spent brainstorming with colleagues to explore material, plan, and come up with creative ways of presenting and assessing material (much like participant Raymond’s “code days”). In these ways I hope to maximize my resources and make connections within and beyond my future school environment in order to increase my own understanding of strategies such as PBL and LBD.

In the classroom I will dedicate more time and energy to formative assessment, in efforts to minimize the amount of marks focus and increase academic risk-taking – an issue reported by participants as a major obstacle to effective implementation of SCL strategies. In my opinion, Science – in spite of the level of precision and detail portrayed in pop culture – is a messy subject; engaging in episodes of trial and error is a truer representation of scientific investigation than following step-by-step instructions that result in a pre-set end product. Given my autonomy over the curriculum I will work to cover content that I feel relays the big ideas most effectively, inviting students to choose the ways in which they demonstrate their understanding. In this way,
I can work towards diversifying my portfolio to accommodate for students of a variety of backgrounds, experiences, and learning styles.

Teaching is an incredibly dynamic profession, and I look forward to becoming a member of this ever-evolving educational research community. It is my belief that the purpose of schooling is to promote the development of culturally informed citizens who are curious, resourceful, self-regulated, and effective communicators, and it is my intention to use the knowledge gained from this study to work towards nurturing these qualities in my classroom.

5.3 Recommendations

The following recommendations stem from the broad implications highlighted in section 5.2.1. They are intended as suggestions for relevant stakeholders in the educational research community as a means to respond to the research problem outlined in Chapter One: the promotion of positive student affect towards science learning via increasing teachers’ awareness of and confidence in implementation of student-centered learning strategies.

For teachers, some of the implied challenges outlined in the previous section included an amplified focus on summative assessment, a lack of confidence in employing a facilitator mindset while maintaining effective classroom management, and a lack of time to be dedicated to learning process over product in the science classroom. Some recommendations that may allow teachers to overcome these challenges include increasing focus on formative assessment and anecdotal note-taking versus quantitative grading, increasing self-advocacy for PD in the area of student-centered instruction (including PBL and LBD) in order to build confidence in a facilitator role, and shifting focus from relaying and assessing specific content expectations to spending more time developing context and inquiry-based learning around curriculum big ideas. In these ways, teachers may find themselves better equipped to apply a student-centered lens to
the Ontario Science curriculum and may discover an increase in risk-taking, inquiry, and self-regulation in their intermediate science classes.

The recommendation for a reduced focus on summative assessment also applies to school administrators. School administrators should work to support teachers’ efforts in taking a more formative approach to assessment and applying less pressure for students to excel in standardized testing. School administration, as reported by participant Maryanne, can greatly affect school culture; and so, they should be dedicated to creating a climate of support, encouragement, and safety for both students and teachers. It is in this kind of environment where students and teachers are more likely to take risks, make mistakes, and engage in rich learning experiences on a regular basis.

Along the line of professional development, it is my recommendation that policymakers should both mandate and provide more PD opportunities for science educators in the field of SCL. The curriculum prioritizes the promotion of scientific inquiry, but there appears to be a lack of professional learning opportunities available to educate teachers in the ways in which scientific inquiry and SCL may be effectively accomplished in the science classroom. With more opportunities made available in the field of SCL, teachers may feel better equipped to overcome those obstacles expressed by participants both in this study and in the literature.

Finally, teacher education programs should consider working more closely together to ensure consistency in educational standards across Ontario. Teacher instructors should be encouraged to infuse SCL strategies such as PBL and LBD into their curriculum, ensuring that teacher candidates develop a close familiarity with these pedagogies and adopt them as part of their repertoire. In doing so, teacher education programs may better contribute to continuity
across Ontario school boards, increasing the number of educators reporting their use and confidence in implementing SCL across the province.

5.4 Areas for Future Research

In the following section I highlight areas where I feel there to be gaps in knowledge, addressing these gaps as opportunities for future research. I found it particularly interesting to discover how little research in the field of SCL in the science classroom (including both PBL, LBD, or other similar strategies) had been conducted in Canada, let alone Ontario. An Ontarian at McMaster University in Hamilton developed the concept of PBL, yet the vast majority of my research into reported uses of PBL in the science classroom originates from studies conducted in the USA or Australia (ie. Hovey & Ferguson, 2014; Ertmer et al., 2009; Prain & Waldrip, 2008, etc). The reason for this apparent lack of local research is ultimately unclear, but I do believe that a strategy reported to be so effective by teachers across the globe warrants a great deal more attention here in Ontario.

Another area warranting further exploration is into the ideology behind streaming. Though not addressed in much detail in the body of this study, I felt the reported discrepancy between streams to be an area worth investigating. What is it that makes some students seem less curious? Is it perhaps a difference of curricular content or a difference in demographics? I think analysis of the factors contributing to student curiosity and affect towards science learning across streams would be an interesting and worthwhile area for future research.

Finally, I think it would be worthwhile to explore the differences in perspectives on the value of and willingness to implement SCL strategies between new and veteran teachers in the same field. I found some significant divergence across my participant responses and attitudes towards SCL in their science classrooms and the importance of maintaining a facilitator mindset.
Where Raymond and Simon were much more enthusiastic and advocated for the use of strategies such as PBL and LBD in their classrooms, Maryanne demonstrated quite a bit more scepticism. The reasons underlying this contrast is an area that I am interested in investigating further.

It is my hope that this study, though small in sample size, serves to at least begin to narrow the gaps in knowledge that I sought to address.

5.5 Concluding Comments

Science education is about more than playing with chemicals, growing plants, dissecting animals, or building bridges. It is an area of study that inspires creativity on a variety of platforms, requires great amounts of humility and perseverance, and promotes the development of what I feel to be the most important goal of education in general: communication. I will reiterate the quotation presented in Chapter One from the Ontario curriculum (OME, 2008), “[t]he notion of thriving in a science-based world applies as much to a small-business person, a lawyer, a construction worker, a car mechanic, or a travel agent as it does to a doctor, an engineer, or a research scientist” (p. 3). If the point here is that everyone thrives in a science-based world, why is it that intermediate-aged students around the globe – particularly in developed countries such as Canada and the USA – continue to see science education in a negative light? This study aimed to target this problem at a provincial level by understanding the ways in which Ontario science educators use their knowledge of student-centered learning strategies such as problem-based learning and learning by design to overcome this deficit in positive affect. Findings revealed that though teachers are aware and sometimes implement such strategies, there is much progress to be made in the area of teacher understanding and confidence in implementation of effective student-centered instruction in intermediate science teaching practice.
As stated in Chapter One, it is a personal passion of mine to take complex concepts in science and present them to students in differentiated formats, where students are better able to understand, interact with, and make connections across various fields of subject matter. Working towards making science learning accessible for every student regardless of race, culture, gender, or socioeconomic status is a goal I entered my teacher education program with, and one that I intend to continue to pursue throughout my career in education. It is my wish for future teacher-researchers and myself that there be an unfailing commitment to advancement in diversifying science education. I think Maryanne hit the problem on the head when she said, “I thought that if I was a really smart person I should go into science, because that would like, prove to the world how brilliant I was.” It is time we moved away from this elitist view of science education as being only meant for ‘smart people,’ and I firmly believe that moving toward a more student-centered approach to science teaching is a significant leap in the right direction.
References


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Appendix A: Consent Letter

Dear ___________________,

My name is Nicole Teschl and I am a candidate of the Master of Teaching program run by OISE at the University of Toronto. As a passionate advocate for student-centered learning in science education, I am interested in learning how a sample of Grade 9 and 10 Ontario science teachers approach, implement, and experience Problem-Based Learning (or other similar student-centered strategies) in the classroom environment. Findings obtained from this study may be informative for not only current and pre-service science teachers, but for individuals involved in development of curriculum, professional workshops, and resource availability. I believe that your knowledge and experience in the field of science education will provide valuable insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching program. The purpose of this assignment is to allow us to become familiar with a variety of research methods. My data collection will consist of a roughly 60-minute face-to-face interview that will be audio-recorded and transcribed. The date and location of the interview is at your convenience.

The contents of this interview will include a final research paper and informal presentations for classmates and instructors, potentially including a research conference and/or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the audio recording after the paper has been presented and/or published which may take up to five years after the data has been collected.

There may be questions in the interview focusing on personal opinions and introspection about your teaching capabilities that you may feel uncomfortable answering. To address this, you will be provided with the questions ahead of time. There are no other known risks to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Sincerely,

Nicole Teschl

MT Program Contact:

Dr. Angela Macdonald-Vemic,

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Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by Nicole Teschl and agree to participate in an interview for the purposes described. I agree to have the interview audio-recorded.

Signature: ______________________________________

Name (printed): _________________________________

Date: ___________________
Appendix B: Interview Protocol

Thank you for participating in my research study. The aim of this research is to learn how a sample of Grade 9 and 10 Ontario science teachers approach, implement, and experience Problem-based learning (or other similar student-centered strategies) in the classroom environment.

This interview should take approximately 60 minutes, and is comprised of approximately 19 questions. The interview protocol has been divided into 4 sections, beginning with the participant’s background information, followed by questions about their understanding of student-centered learning and PBL, then their experiences and observations involved with planning and implementation of PBL (or similar strategies), and concluding with questions regarding supports, challenges, and next steps for teachers. I want to remind you that you can choose not to answer any question, and can remove yourself from participation at any time.

Do you have any questions before we begin?

To begin can you state your name for the recording?

Section A – Background Information

1. How long have you been working as a teacher in Ontario?
   a) What school board do/have you currently/most recently work(ed) for?
   b) How long have you been teaching intermediate science?
   c) Have you taught any other subjects?
   d) Have you taught in any other boards (other than _____)?
      i. If so, where? Do you recall any key differences across boards relevant specifically to your position teaching science (ie. differences in funding, demographics, staff/parent support etc.)?

2. Do you enjoy teaching science? Why or why not?
   a) What is your favourite thing about teaching science?
   b) What is your least favourite thing about teaching science?

3. Did you enjoy science learning as an intermediate student? Why or why not?

4. Did you pursue a degree/diploma in science in University/college (outside of your teacher education program)? Why or why not?
   a) If so, what specific area of science did you pursue (ex. biology, chemistry, environmental, etc.)
   b) If not, what area of study did you pursue?
Section B – Understanding of and perspectives on student-centered learning

5. How would you describe your teaching philosophy?

6. How would you define “student-centered learning” and “problem-based learning” (referred to as PBL)?
   a) Where have you come across these terms before?
   b) How do these terms align with your overall teaching philosophy?

9. I myself am a highly visual learner. Would you mind providing me with a description of your classroom set-up?

10. Can you describe to me some student-centered learning strategies that you are familiar with (ex. Know of, have used, have seen used, are planning to use, etc.)?

11. How would you describe your students’ overall enthusiasm and/or engagement in science?
    a) Why do you think this is the case? (ex. curriculum, resources, teaching style, parental/peer influences, etc)

Section C – Experiences with implementation of PBL

12. Can you describe a time when you used a student-centered learning strategy in your intermediate science classroom (ex. lesson, activity, unit, etc.)?
    Prompt: materials, resources, learning goals, set-up, etc.
    a) Was the experience a positive or negative one?
    b) How would you describe the reaction of your students to the lesson/activity/unit/etc.?
       (ex. Excitement, boredom, apprehension, etc.)

13. Can you walk me through a time when you used PBL (problem OR project-based) specifically (ie. as a lesson/activity/unit) in teaching a scientific concept in your classroom?
    a) Why did you decide to go with this strategy? (ie. Asked by principal, personal choice, previous experience was a success, etc.)
    b) How did you go about planning your lesson/activity/unit?
       Prompt: materials, resources, learning goals, set-up, etc.)
    c) Were you satisfied with the results? Why or why not?

14. What would you say is the single most important factor to consider in the planning and implementation of PBL? Why is that?

Section D – Supports, Challenges, and Next Steps

15. As a teacher employed by the (school board), do you feel generally supported in your efforts to use PBL?
    a) Can you elaborate on a specific experience where you felt supported/unsupported?
16. Have you ever attended a professional development workshop (or anything of the sort) focused on PBL/student-centered learning and science education?
   a) If so, can you please describe what the experience entailed?
   b) If not, would you be interested in having opportunities like this available?

17. Can you describe to me any barriers or challenges that you encountered during your experiences planning and implementing PBL?
   a) How have you managed these in the past?

18. Have you ever received any feedback regarding your efforts/results in implementing PBL or another similar strategy?
   Prompt: colleague/principal/parent/student?
   a) If so, how did the feedback make you feel?
   b) If not, would you have liked to have received some feedback? Do you think it would have been beneficial?

19. What advice would you provide for a new teacher looking to incorporate PBL or other such student-centered learning strategies into their future intermediate science classroom?

Thank you, sincerely, for your time and considered responses.